Persistent luminescence and mechanoluminescence in $MSi_2O_2N_2:Eu^{2+}$ (M = Ca, Sr, Ba)

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Europium doped oxynitrides of the form $MSi_2O_2N_2:Eu^{2+}$ (with M = Ca, Sr, Ba) are recently proposed to be excellent conversion phosphor materials for white-light-emitting LED applications based on near ultraviolet (UV) or blue emitting InGaN LEDs. This is not only because of their strong absorption in the near UV to blue-light region of the light spectrum, but also for their high quantum efficiency and good thermal and chemical stability compared to oxide and sulfide phosphors. [1, 2]

All three $MSi_2O_2N_2:Eu^{2+}$ compounds show persistent luminescence. This is a disadvantage when it comes to applying the materials in a phosphor converted white LED. Figure 1a and 1b show the persistent luminescent intensity as a function of time for the different materials after 30 seconds of excitation with 280 nm UV radiation and 425 nm violet light respectively. After excitation with 280 nm, all materials show persistent luminescence. Upon excitation with 425 nm, only $BaSi_2O_2N_2:Eu^{2+}$ show an appreciable afterglow. The $SrSi_2O_2N_2:Eu^{2+}$ and $CaSi_2O_2N_2:Eu^{2+}$ compounds show an afterglow which is over one hundred times weaker than the afterglow after 280 nm excitation and is well below 0.32 mcd/cm², a threshold value often used in industrial standards. This makes only $SrSi_2O_2N_2:Eu^{2+}$ and $CaSi_2O_2N_2:Eu^{2+}$ suitable as conversion phosphors in combination with a blue pumping LED if any afterglow should be avoided.

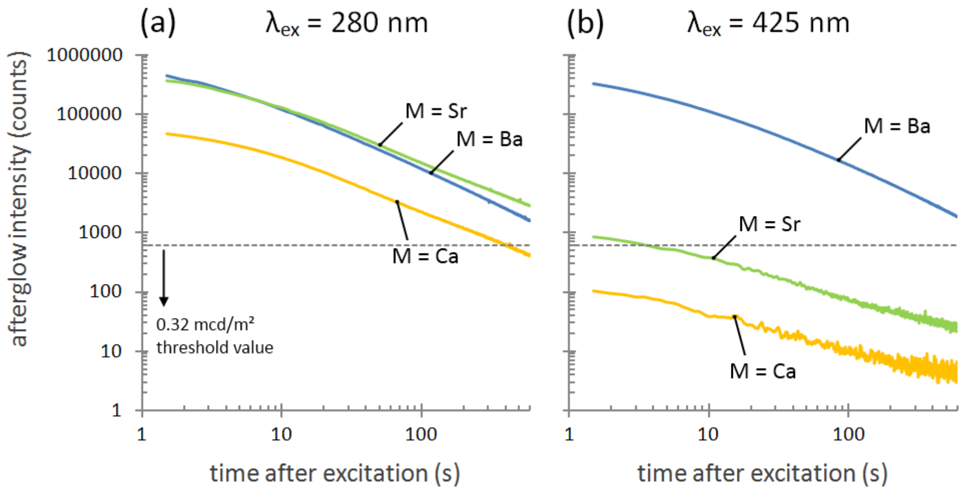

Figure 1: Decay of the afterglow of $MSi_2O_2N_2:Eu^{2+}$ (with M = Ba, Sr, Ca) after 30 sec. excitation with 280 nm UV radiation (a) and 425 nm violet light (b).

Beside its persistent luminescent property, $BaSi_2O_2N_2:Eu^{2+}$ shows strong luminescence upon mechanical stimulation such as friction or pressure. This phenomenon, known as non destructive mechanoluminescence (ML), is not so common and might have application in pressure sensing devices. The mechanoluminescence emission spectrum is similar to the photoluminescence (PL) emission spectrum except for a shift towards longer wavelengths of about 4 nm (figure 2). This makes the spectrum identical to that of the persistent luminescence, suggesting that the same radiative recombination path is present for the mechanoluminescence and the persistent luminescence.

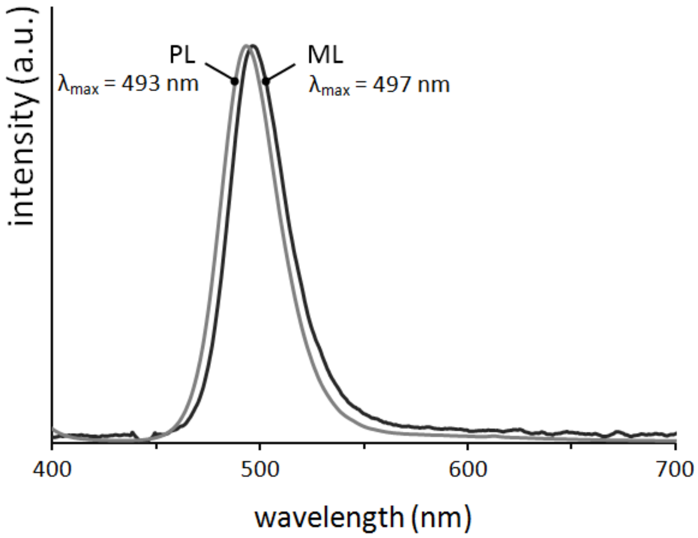

Figure 2: PL (excited at 370 nm) and ML emission spectra of $BaSi_2O_2N_2:Eu^{2+}$.

[1] P.F. Smet *et al.*, *J. Electrochem. Soc.* **158** (2011) R37-R54.

[2] V. Bachmann *et al.*, *Chem. mater.* **21** (2009) 316-325.

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